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(54) ENGINE VALVE CONTROL MECHANISM

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USPC 123/90.39, 90.44, 90.45
See application file for complete search history.

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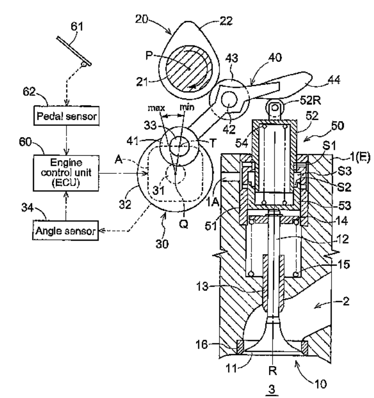
(57) **ABSTRACT**

A valve control mechanism is configured that is capable of optimally controlling an engine by lifting an intake valve only by the necessary amount, while suppressing noise at the time of operation. This valve control mechanism includes a control member that rotates around a control axis due to a driving force of an actuator, and a base end portion of a rocker arm is pivotably supported around a pivot axis by an eccentric support portion of the control member. The rocker arm is pivoted by a cam portion of a camshaft abutting against an intermediate roller of the rocker arm, and an operation of opening the intake valve is performed due to a pressure force from the pivot end. The rocker arm is shifted in the longitudinal direction due to an operation of the actuator, and control for changing the lift amount of the intake valve is performed.

6 Claims, 8 Drawing Sheets



(51) **Int. Cl.**
F01L 1/24 (2006.01)
F01L 1/22 (2006.01)

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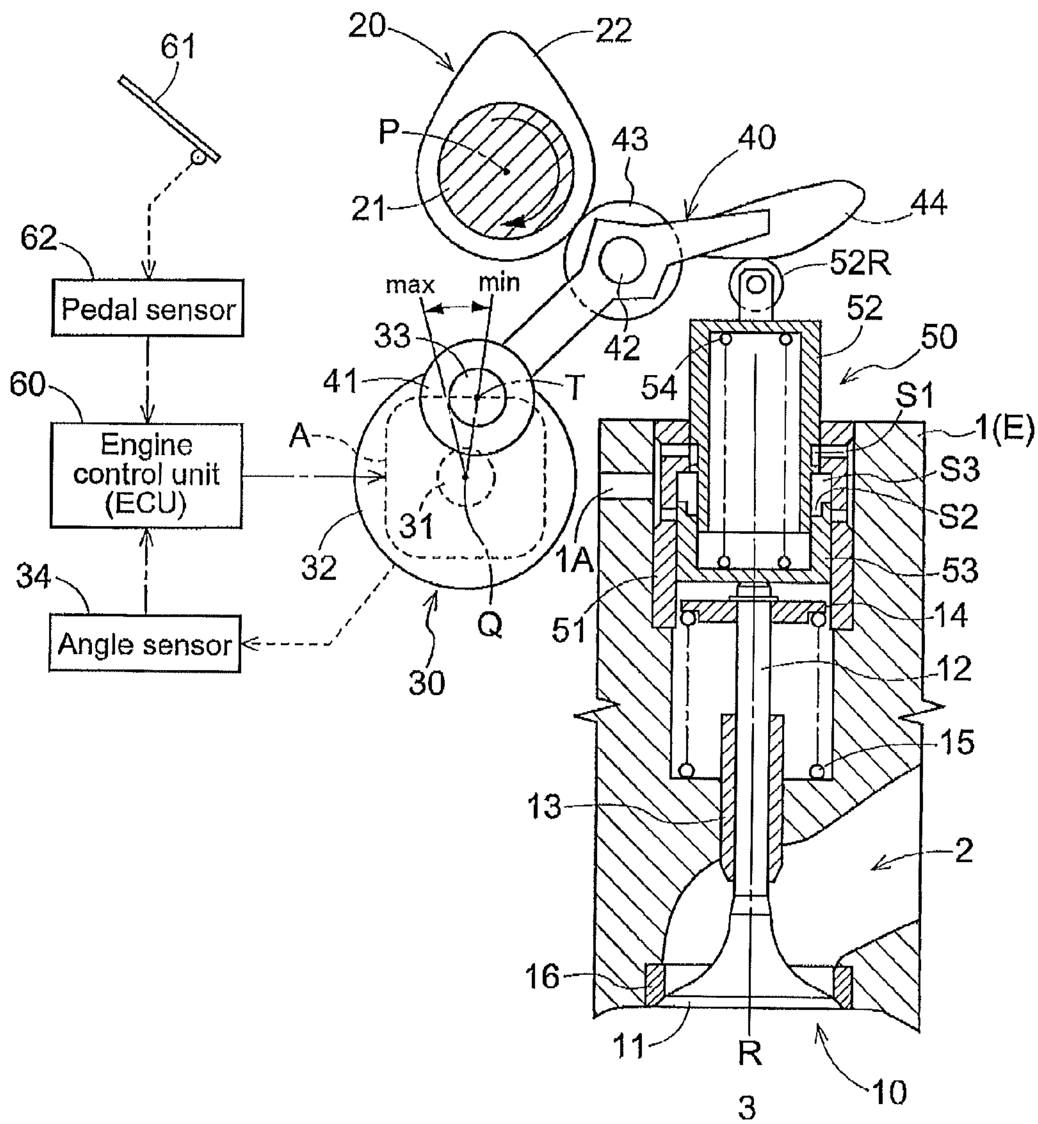
Fig.1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62
Pedal sensor
60
Engine control unit (ECU)
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Angle sensor
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P
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33
41
T
42
52
50
54
S1
1(E)
A
S3
S2
31
32
Q
30
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53
51
14
12
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13
2
16
11
R
10
3

Fig.2

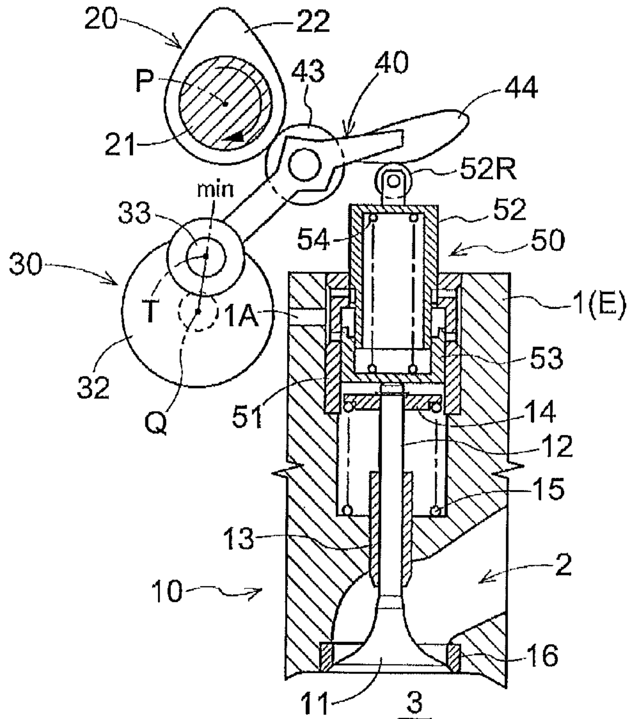
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Fig.3

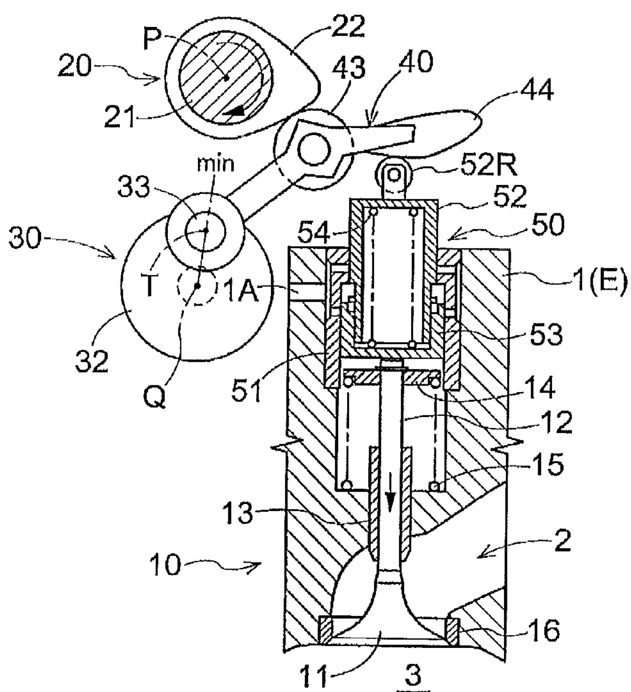
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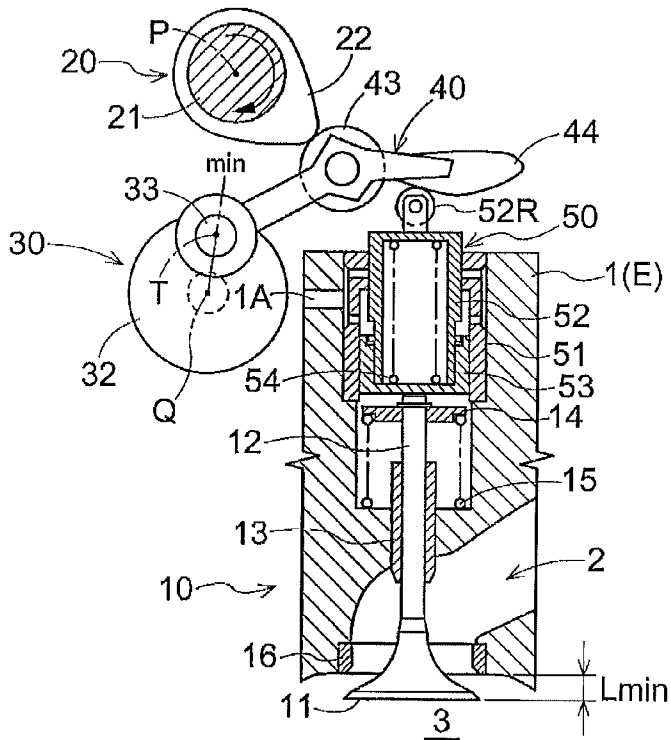
Fig.4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Lmin
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Fig.5

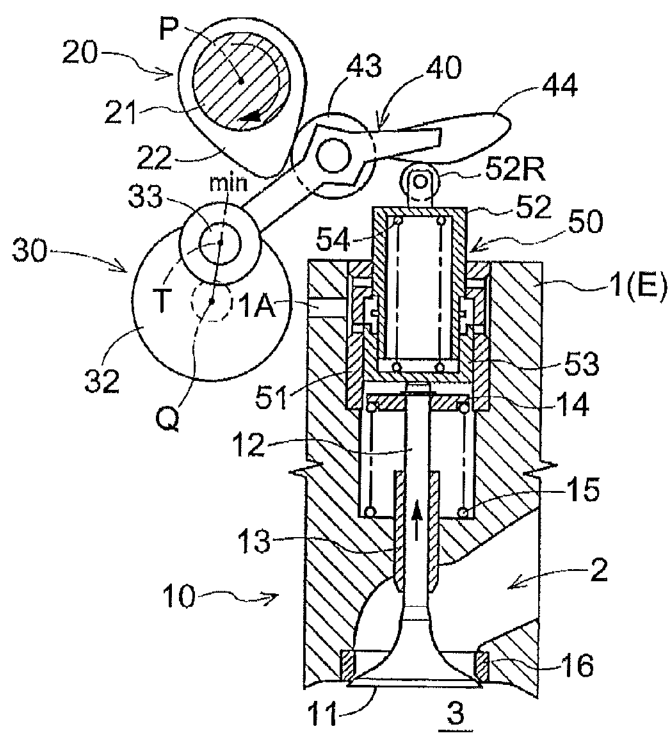
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Fig.6

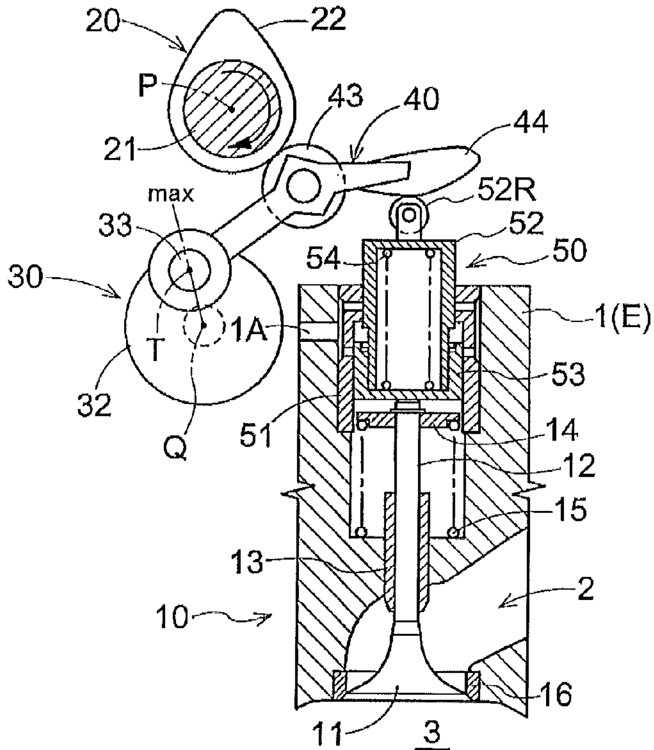
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Fig.7

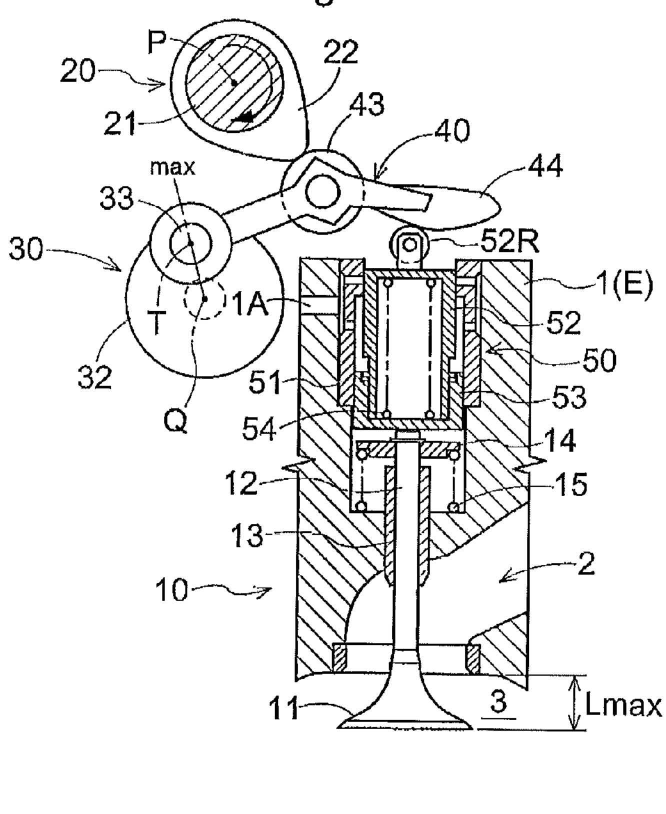
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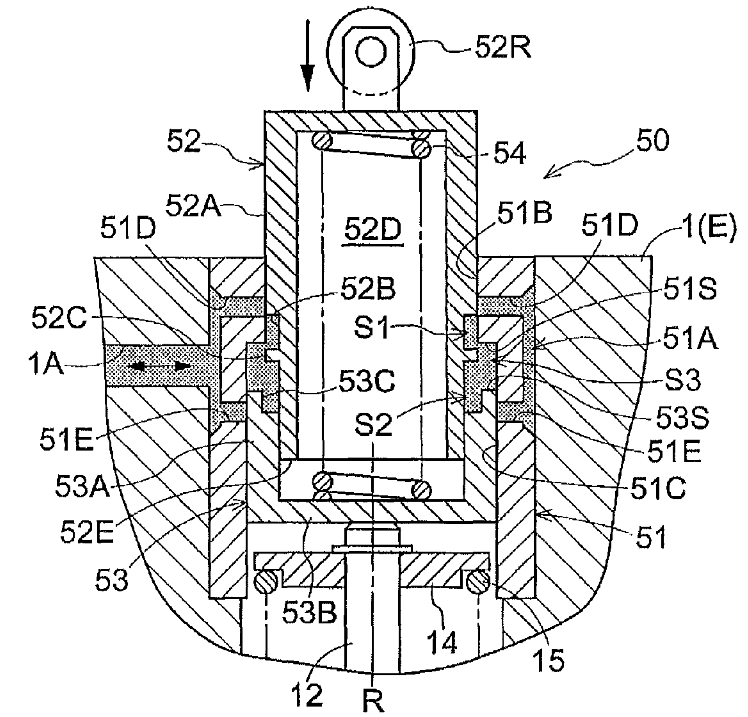
Fig.8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S2
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51C
52E
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53B
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12
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Fig.9

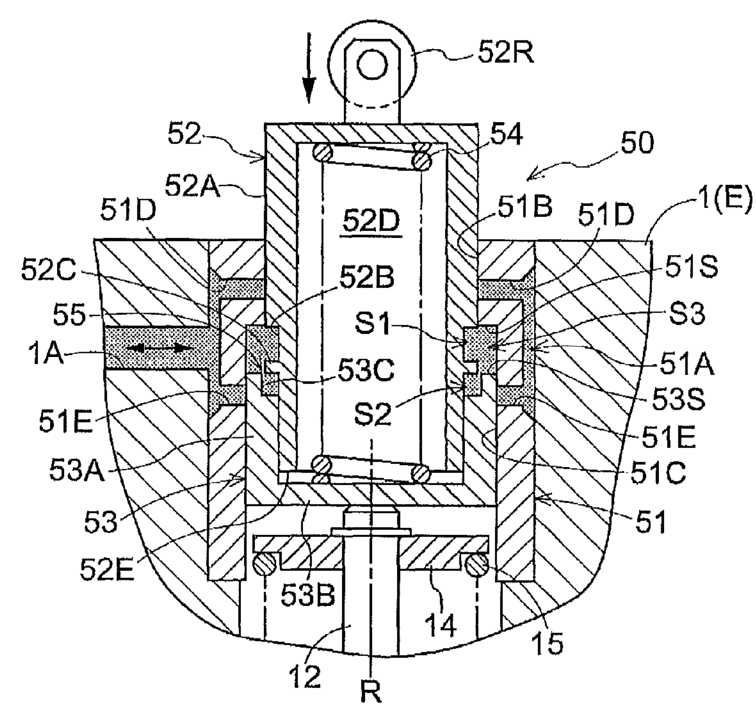
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Fig.10

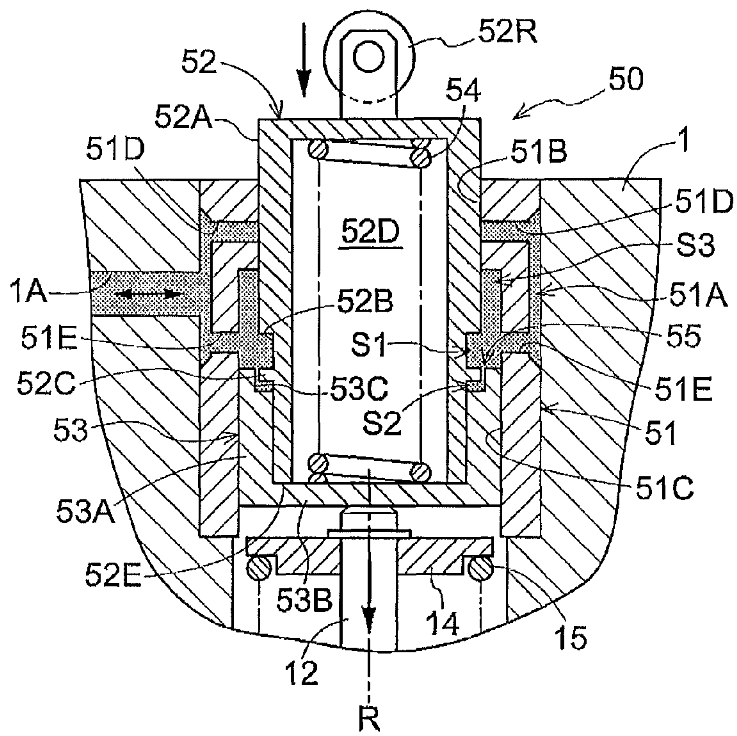
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Fig.11

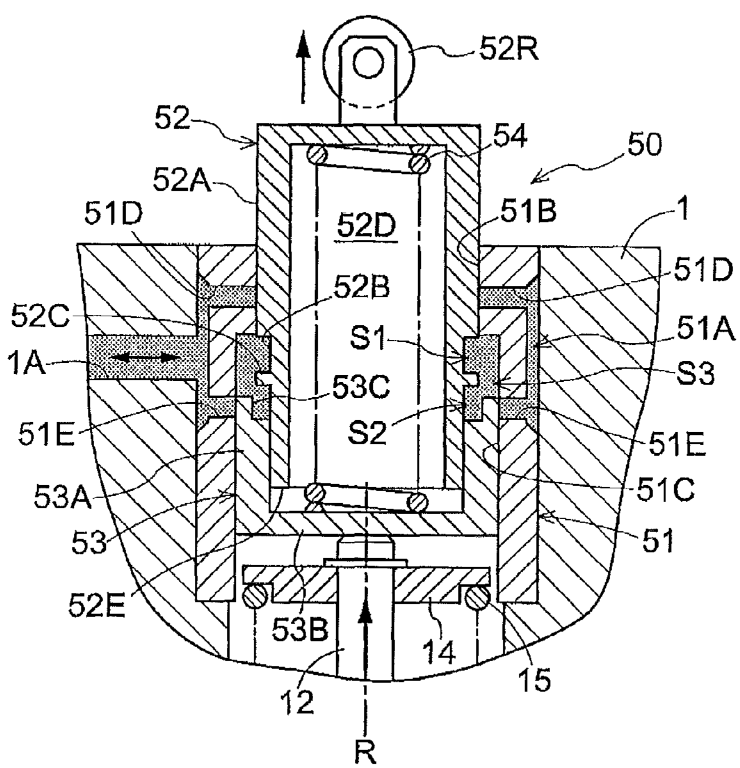
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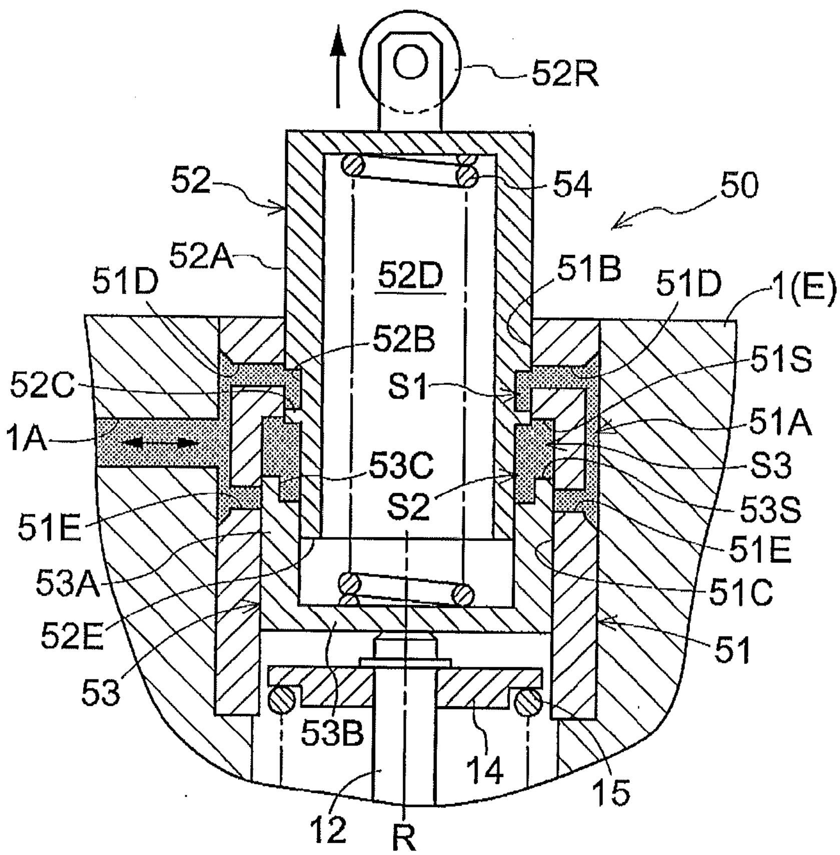
Fig.12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51C
52E
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53B
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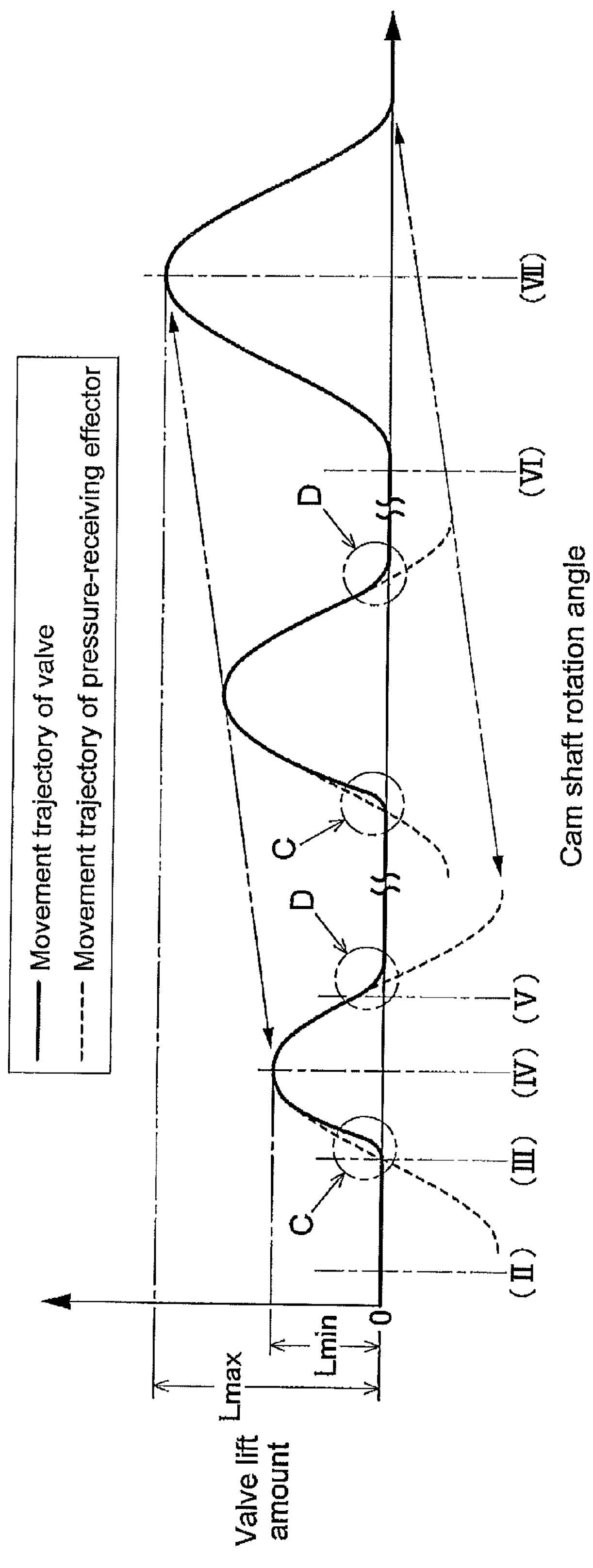
15
12
R

Fig.13


Movement trajectory of valve
Movement trajectory of pressure-receiving effector
Valve lift amount
Lmax
Lmin
0
C
D
C
D
(II)
(III)
(IV)
(V)
(VI)
(VII)
Cam shaft rotation angle

ENGINE VALVE CONTROL MECHANISM

TECHNICAL FIELD

The present invention relates to an engine valve control mechanism, and more particularly to a technique for adjusting a lift amount of at least one of an intake valve and an exhaust valve.

BACKGROUND ART

PTL 1 discloses, as an engine valve control mechanism configured as mentioned above, a configuration provided with a hydraulic cylinder that drives the rocker shaft to rotate and in which a middle/high-speed rocker arm is fitted into an eccentric large-diameter portion of a rocker shaft. In this configuration, the middle/high-speed rocker arm is supported by the eccentric large-diameter portion of the rocker shaft via an eccentric bushing, the middle/high-speed rocker arm is entirely shifted by driving the rocker shaft to rotate so as to change the cam lift amount, and consequently a change of settings of the valve lift amount and the valve timing is realized.

CITATION LIST

Patent Literature

PTL 1: JP H5-179912A

SUMMARY OF INVENTION

Technical Problem

As disclosed in PTL 1, in an operation mode in which an end portion of the rocker arm is caused to abut against a projecting end of a valve so as to open the valve due to exertion of a pressure force, a knocking sound is generated when the end portion of the rocker arm abuts against the projecting end of the valve. A configuration in which a knocking sound is thus generated will increase an engine sound, and there is room for improvement.

Moreover, since the entire rocker arm is shifted in PTL 1, a configuration is employed in which the eccentric bushing is provided in the rocker shaft and a base end portion of the rocker arm is fitted onto the eccentric bushing. To significantly shift the rocker arm in this configuration, the eccentric bushing has a large diameter, and a ring-like support portion fitted onto this eccentric bushing also has a large diameter. There is room for improvement in this aspect as well.

An object of the present invention is to reasonably configure a valve control mechanism capable of optimally controlling an engine by lifting a valve only by a necessary amount while suppressing noise at the time of operation.

Solution to Problem

A feature of the present invention lies in including: a camshaft driven to rotate; a rocker arm that pivots around a pivot axis of a base end portion of the rocker arm in accordance with a rotation of the camshaft; a shift unit that shifts the rocker arm in a longitudinal direction of thereof; and a lash adjuster that abuts against another end portion of the rocker arm and transmits a pressure force from the rocker arm to a valve. The shift unit includes a control member rotatably supported around a control axis parallel with the pivot axis and pivotably supporting the base end portion of the rocker arm with respect to an eccentric support portion which is eccentric from the control axis, and the control member rotates around the control axis by an actuator.

With this configuration, the rocker arm pivots around the pivot axis of the base end portion with a rotation of the camshaft, the pressure force from the pivot end of the rocker arm is transmitted from the lash adjuster to the valve, and the valve opening operation is performed due to this pressure force. The lash adjuster suppresses the impact from the rocker arm, and therefore noise decreases. Furthermore, the rocker arm is shifted in the longitudinal direction thereof in a mode of displacing the position of the pivot axis of the base end portion of the rocker arm by using a driving force of the actuator to rotate the control member of the shift unit. Thus, the distance between the position on the rocker arm against which a cam portion of the camshaft abuts and the position of the pivot axis is changed, the amount of pivoting of the rocker arm is changed, and the lift amount of the valve can thus be changed. In particular, with this configuration, the timing of opening and closing the valve can also be changed by changing the timing of the pressure force being exerted on the valve from the camshaft.

With this configuration, in which the control member supports the base end portion of the rocker arm around the pivot axis, a reduction in size of the shift unit is realized, as compared with a configuration in which the control member is configured on an eccentric member and a ring-like support structure fitted onto this eccentric member is formed in the rocker arm, for example.

Accordingly, a small valve control mechanism capable of optimally controlling the engine by lifting the valve only by the necessary amount while suppressing noise at the time of operation is configured. In particular, with this configuration, the timing of opening and closing the valve can also be changed in conjunction with the change of the lift amount of the valve, and the air intake timing and the exhaust timing can be set optimally.

The present invention may further include a control unit that, in a case where the valve is configured as an intake valve of an engine and an accelerator operation tool is operated in an accelerating direction, operates the actuator so as to increase an amount of air intake by the intake valve with an increase in an operation amount of the accelerator operation tool and shifts the rocker arm.

With this configuration, when the accelerator operation tool is operated in an accelerating direction, the control unit controls the actuator, thereby shifting the rocker arm so as to increase the amount of air intake by the intake valve. Thus, the air intake amount can be reduced in the case of not accelerating the engine and can be increased in the case of accelerating the engine, and adjustment of the rotational speed of the engine is also realized by adjusting the air intake amount by means of adjustment of the lift amount of the intake valve, without adjusting the air intake amount with a throttle valve provided in an intake system. Furthermore, air intake resistance at the throttle valve is reduced, pumping loss is consequently reduced, and thus an improvement in fuel efficiency is also realized.

The present invention may further include an intermediate roller provided rotatably around an axis parallel with the pivot axis, in an intermediate part of the rocker arm and at a position where a cam portion of the camshaft can abut against the intermediate roller.

With this configuration, since the cam portion of the camshaft abuts against the intermediate roller at the intermediate part of the rocker arm, smooth abutting is realized at the time of this abutting, due to the rotation of the intermediate roller, and friction can be suppressed.

In the present invention, the lash adjuster may have, in a relatively movable manner, a pressure-receiving effector that operates when receiving a pressure force from the rocker arm, and a relay effector that transmits an operating force from the pressure-receiving effector to the valve, and have an intermediate spring that biases the pressure-receiving effector and the relay effector in separate directions, and the lash adjuster may have an orifice portion that suppresses, when the pressure-receiving effector is displaced in a direction of approaching the relay effector, an outflow of a fluid from a pressure receiving-side damper space formed in an insertion portion where the pressure-receiving effector and the relay effector are fitted to each other.

With this configuration, the pressure-receiving effector and the relay effector relatively move in separate directions due to a biasing force of the intermediate spring, and a state can be maintained where the pressure-receiving effector is caused to project such that the pressure-receiving effector and driving mechanisms such as the rocker arm and the cam are caused to come into contact with each other. Furthermore, when a pressure force is exerted on the pressure-receiving effector from the driving mechanisms such as the rocker arm and the cam, the pressure force exerted on the pressure-receiving effector is exerted on the relay effector via a fluid in the pressure receiving-side damper space, and is then exerted from this relay effector in a direction of opening the valve. When the pressure force is exerted on the valve from the relay effector, the fluid within the pressure receiving-side damper space flows out of the orifice portion, and thereby releases part of the pressure force exerted on the relay effector from the pressure-receiving effector and absorbs the impact.

In the present invention, the intermediate roller may be always in contact with the cam portion.

With this configuration, since the intermediate roller is always in contact with the cam portion, an impact sound is not generated from the contacting portion between the intermediate roller and the cam portion even if the cam portion rotates, and a significantly quiet valve control mechanism can be provided. Furthermore, since the intermediate roller is a rotational body, friction at the contacting portion between the intermediate roller and the cam portion can be suppressed to the minimum amount necessary.

In the present invention, an abutting body of the rocker arm may be always in contact with a pressure-receiving roller provided in the pressure-receiving effector.

With this configuration, since the abutting body of the rocker arm is always in contact with the pressure-receiving roller, an impact sound is not generated from the contacting portion between the abutting body and the pressure-receiving roller even if the abutting body slides, and a significantly quiet valve control mechanism can be provided. Furthermore, since the pressure-receiving roller is a rotational body, friction at the contacting portion between the pressure-receiving roller and the abutting body can be suppressed to the minimum amount necessary.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a diagram showing a configuration of an engine valve control mechanism.

FIG. **2** is a cross-sectional view of a lash adjuster and a valve in a closed state, in a state where an eccentric support portion is at a minimum position.

FIG. **3** is a cross-sectional view of the lash adjuster and the valve whose opening operation has been started, in a state where the eccentric support portion is at the minimum position.

FIG. **4** is a cross-sectional view of the lash adjuster and the valve that has reached an opened state, in a state where the eccentric support portion is at the minimum position.

FIG. **5** is a cross-sectional view of the lash adjuster and the valve that has restored the closed state from the opened state, in a state where the eccentric support portion is at the minimum position.

FIG. **6** is a cross-sectional view of the lash adjuster and the valve in the closed state, in a state where the eccentric support portion is at a maximum position.

FIG. **7** is a cross-sectional view of the lash adjuster and the valve that has reached the opened state, in a state where the eccentric support portion is at the maximum position.

FIG. **8** is a cross-sectional view of the lash adjuster immediately after a pressure force is exerted on a pressure-receiving effector.

FIG. **9** is a cross-sectional view of the lash adjuster in a state where a second damper space accomplishes a damper function.

FIG. **10** is a cross-sectional view of the lash adjuster in a state where a pressure force is directly transmitted from the pressure-receiving effector to a relay effector.

FIG. **11** is a cross-sectional view of the lash adjuster immediately after the relay effector starts a projecting operation due to a biasing force of a valve spring.

FIG. **12** is a cross-sectional view of the lash adjuster when the relay effector performs the projecting operation.

FIG. **13** is a diagram showing a change of the valve lift amount when the eccentric support portion is changed from the minimum position to the maximum position.

DESCRIPTION OF EMBODIMENTS

Hereinafter, an embodiment of the present invention will be described based on the drawings.

Basic Configuration

FIG. **1** shows a valve control mechanism for a four-stroke cycle engine E equipped with an intake valve **10** of the engine E, a camshaft **20**, a shift unit **30**, a rocker arm **40**, a lash adjuster **50**, and an engine control unit **60** serving as a control unit (ECU) that controls the lift amount of the intake valve **10**.

The valve control mechanism is configured such that a cam portion **22** of the camshaft **20** abuts against an intermediate roller **43** at an intermediate position on the rocker arm **40** in the longitudinal direction thereof, and the rocker arm **40** thereby pivots around a pivot axis T. In the valve control mechanism, an abutting body **44** at a pivot end of the rocker arm **40** is disposed close to the lash adjuster **50**, and an operation of opening the intake valve **10** is performed by transmitting, when a pressure force is exerted from the abutting body **44** with a pivot of the rocker arm **40**, the pressure force from the lash adjuster **50** to the intake valve **10**, while absorbing the impact.

In this valve control mechanism, a control member **32** of the shift unit **30** is rotatably supported around a control axis Q, and a base end portion of the rocker arm **40** is pivotably supported around the pivot axis T by an eccentric support portion **33** that is eccentric from the control axis Q. The valve control mechanism shifts the rocker arm **40** in the longitudinal direction by the control member **32** rotating due to being driven by an actuator A, continuously adjusts the lift amount of the intake valve **10**, and also changes the air intake timing in conjunction with this adjustment.

A description will be given later of a specific operation mode, in which, while the camshaft **20** rotates once, the lift amount is changed due to a change of an operation stroke exerted on the intake valve **10** from the camshaft **20**, and the opening timing and the opening duration time of the intake valve **10** are changed due to a change of an area (operation angle) in which the pressure force is exerted on the intake valve **10** from the camshaft **20**. The operation angle indicates an area at the rotation angle of the camshaft **20** when the intake valve **10** is in an opened state, and the timing (rotation angle of the camshaft **20**) at which the lift amount is largest is also necessarily changed due to the change of this operation angle. Note that a cam axis P of the camshaft **20**, the control axis Q, and the pivot axis T are set in a mutually parallel orientation.

The engine control unit **60** detects the amount of a stepping operation on an accelerator pedal **61** (an example of an accelerator operation tool) of a vehicle, using a pedal sensor **62**, shifts the rocker arm **40** in the longitudinal direction by controlling the actuator A based on a detected value, and adjusts the pivot amount of the rocker arm **40** at the time when the cam portion **22** of the camshaft **20** abuts against the intermediate roller **43**. With this adjustment, the lift amount of the intake valve **10** is set to a target value, and simultaneously, the air intake amount and the air intake timing of a combustion chamber **3** of the engine E are controlled by setting the air intake timing, and consequently the control of the rotational speed of the engine E is realized.

The valve control mechanism may be provided not only for the above-described intake valve **10** but also for an exhaust valve, and may be provided for both the intake valve and the exhaust valve. The details of the valve control mechanism will be described below.

Intake Valve

The intake valve **10** has a shape obtained by integrally forming a valve head **11** that expands in an umbrella shape on the lower end side and a shaft-like valve stem **12** that is continuous with the valve head **11**. The intake valve **10** is supported in a mode in which the valve stem **12** is slidably inserted into a valve guide **13** provided in a cylinder head **1**.

A compression coil-type valve spring **15** is provided between a stopper **14** at the upper end of the valve stem **12** and the cylinder head **1**, and the intake valve **10** is maintained in a closed state by the valve head **11** abutting against a valve seat **16** at a boundary position between an intake passage **2** and the combustion chamber **3** due to a biasing force of the valve spring **15**.

Camshaft and Shift Unit

The camshaft **20** includes a camshaft portion **21** and the cam portion **22** projecting from the outer circumference thereof. The camshaft portion **21** is supported by the cylinder head **1** so as to rotate around the cam axis P due to a driving force transmitted from a crankshaft (not shown) by a timing chain (not shown).

This valve control mechanism may include a variable valve timing system that changes a relative rotational phase of the cam portion **22** with respect to a driving system constituted by the timing chain and the camshaft **20**. An exemplary variable valve timing system is constituted by a driving-side rotational member that rotates integrally with a sprocket around which the timing chain is wound, a driven-side rotational member that rotates integrally with the camshaft **20**, and an actuator that changes a relative rotation angle therebetween.

With the variable valve timing system, the air intake timing can be optimally set based on the rotational speed of the engine E, the load exerted on the engine E, and the like, and for example, the torque at the time of low-speed running can be increased, and the startability of the engine E can be improved. Note that the variable valve timing system may be provided in an exhaust camshaft, and both a hydraulic actuator and an electric actuator can be used.

The shift unit **30** includes the eccentric support portion **33** that rotatably supports the disk-like control member **32** around the axis (control axis Q) of a shaft body **31** supported by the cylinder head **1**, and that has a shaft shape in a parallel orientation with respect to the control axis Q in an outer-circumferential portion of the control member **32**. This shift unit **30** includes the electric motor-type actuator A that rotates the control member **32** with respect to the shaft body **31**, and includes an angle sensor **34** that detects the rotation amount of the control member **32** with respect to the shaft body **31**.

Note that the actuator A in the shift unit **30** may be a hydraulic actuator, and in the case of using the hydraulic actuator, the same configuration as that of an actuator used in a hydraulic variable valve timing system can be used.

Rocker Arm

The rocker arm **40** has, at the base end portion thereof, a ring-like loosely-fitted portion **41** that is loosely fitted to the eccentric support portion **33**, rotatably supports, at an intermediate position in the longitudinal direction, the intermediate roller **43** around a spindle **42** in a parallel orientation with respect to the cam axis P, and has the abutting body **44** on the pivot end side that is opposite to the base end portion.

The loosely-fitted portion **41** of the rocker arm **40** is rotatably supported with respect to the eccentric support portion **33** of the shift unit **30**, and the rocker arm **40** is thereby supported around the pivot axis T. The cam portion **22** of the camshaft **20** abuts against the intermediate roller **43**, and the abutting body **44** thereby pivots so as to be displaced downward. With this pivot, the pressure force from the abutting body **44** is transmitted to the lash adjuster **50** and further to the intake valve **10**, and the intake valve **10** is opened.

The abutting body **44** has an arc-shaped abutting face that moderately projects downward, and is configured so as not to move, upward or downward, the position where the abutting body **44** abuts against the lash adjuster **50** even when the rocker arm **40** shifts in the longitudinal direction.

Lash Adjuster

As shown in FIG. **8**, the lash adjuster **50** has a configuration in which a pressure-receiving effector **52** and a relay effector **53** are inserted in a slidable state and in a relatively movable manner, into a sleeve member **51** that is fitted and fixed to the cylinder head **1** serving as a fixture system. The sleeve member **51**, the pressure-receiving effector **52**, and the relay effector **53** are disposed coaxially with a valve axis R of the valve stem **12** of the intake valve **10**, and the pressure-receiving effector **52** and the relay effector **53** are supported so as to be able to move back and forth along the valve axis R. A fluid space S1, a pressure receiving-side damper space S2, and a restoring-side damper space S3 are formed. The lash adjuster **50** also includes an oil passage system that supplies and discharges oil serving as a working fluid to and from the aforementioned spaces. While the lash adjuster **50** works regardless of the orientation thereof, the positional relationship, configurations, and the like will be described based on the orientation shown in FIG. **8**.

The sleeve member **51** is formed in a ring shape as a whole, and a storage space **51**A that stores the oil is formed in an outer-circumferential portion of the sleeve member **51** as a result of the diameter of the outer-circumferential portion thereof being partially reduced. An oil passage **1**A for supplying the oil from a hydraulic pump (not shown) to the storage space **51**A is formed in the cylinder head **1**. A small diameter portion **51**B is formed on the upper side (opposite side to the intake valve **10**) within the sleeve member **51**, and a large diameter portion **51**C is formed below the small diameter portion **51**B. In the sleeve member **51**, a first supply and discharge passage **51**D that is in communication with the small diameter portion **51**B from the storage space **51**A is formed as an oil supply passage for supplying the oil to the pressure-receiving effector **52** and the relay effector **53**, and a second supply and discharge passage **51**E that is in communication with the large diameter portion **510** from the storage space **51**A is formed. Note that although an oil pump driven by the engine E is assumed here, an oil pump driven by an electric motor may also be used.

The pressure-receiving effector **52** has a tubular outer-circumferential face, and a pressure-receiving roller **52**R that receives pressure from the abutting body **44** of the rocker arm **40** is rotatably supported at an upper end position of the pressure-receiving effector **52**. A lower outer face **52**B whose diameter is smaller than that of an upper outer face **52**A is formed, and a control body **52**C that vertically divides the lower outer face **52**B into two parts is formed so as to project outward from the lower outer face **52**B. A spring housing space **52**D is formed inside the pressure-receiving effector **52**, and a compression coil-type intermediate spring **54** is housed therein. The intermediate spring **54** is interposed between the pressure-receiving effector **52** and the relay effector **53**, and exerts a biasing force that causes the pressure-receiving effector **52** to project upward. An abutting portion **52**E is formed at the lower end of the pressure-receiving effector **52**.

The outer diameter of the upper outer face **52**A of the pressure-receiving effector **52** is set to a value that is slightly smaller than the inner diameter of the small diameter portion **51**B of the sleeve member **51**, and the pressure-receiving effector **52** is thereby supported movably in a direction along the valve axis R.

The relay effector **53** has a tubular portion **53**A and a bottom wall portion **53**B in a lower part and is thereby formed in a tubular shape with a bottom, and a step-like portion **53**C that the control body **52**C of the pressure-receiving effector **52** can enter is formed on the inner circumference at the upper end (opposite side to the intake valve **10**) of the tubular portion **53**A. The intermediate spring **54** is disposed between the upper face of the bottom wall portion **53**B of the relay effector **53** and the upper wall of the pressure-receiving effector **52**, and the relay effector **53** is disposed at a position where the upper end of the valve stem **12** of the intake valve **10** abuts against the bottom face of the bottom wall portion **53**B.

A spring having a small biasing force (with a small spring constant) as compared with the valve spring **15** is used as the intermediate spring **54**.

The outer diameter of the tubular portion **53**A of the relay effector **53** is set to a value that is slightly smaller than the inner diameter of the large diameter portion **51**C of the sleeve member **51**, and the inner diameter of the tubular portion **53**A is set to a value that is slightly larger than the outer diameter of the lower outer face **52**B of the pressure-receiving effector **52**. Thus, the relay effector **53** is relatively movable in a direction along the valve axis R with respect to the sleeve member **51** and the pressure-receiving effector **52**.

An area of the lower outer face **52**B of the pressure-receiving effector **52** above the control body **52**C is referred to as the fluid space S**1**, and an area thereof below the control body **52**C is referred to as the pressure receiving-side damper space S**2**. Note that the pressure receiving-side damper space S**2** is formed in a portion where the pressure-receiving effector **52** is inserted into the relay effector **53**. The restoring-side damper space S**3** is formed in an area sandwiched between a step-like face **51**S on the boundary between the small diameter portion **51**B and the large diameter portion **51**C of the sleeve member **51** and an upper end face **53**S of the relay effector **53** on the upper-end outer circumference thereof.

With the lash adjuster **50**, when pressure is not exerted on the pressure-receiving roller **52**R from the abutting body **44** of the rocker arm **40**, a state is maintained where the pressure-receiving effector **52** projects upward due to the biasing force of the intermediate spring **54** and causes the pressure-receiving roller **52**R to abut against the abutting body **44** of the rocker arm **40**. At the time of this projection, when the first supply and discharge passage **51**D is in a positional relationship in which it is in communication with the fluid space S**1**, the pressure-receiving effector **52** projects upward in a state where pressure from the oil is also exerted thereon. Next, when pressure is exerted on the pressure-receiving roller **52**R from the abutting body **44** of the rocker arm **40** and the pressure-receiving effector **52** approaches the relay effector **53**, the outer-circumferential face of the pressure-receiving effector **52** blocks the first supply and discharge passage **51**D, and the oil flowing in and out of the fluid space S**1** is blocked. Thereafter, when the pressure-receiving effector **52** further approaches the relay effector **53**, the above-described state is switched to a state where the restoring-side damper space S**3** is in communication with the second supply and discharge passage **51**E. The pressure-receiving effector **52** that thus controls the oil flow in the first supply and discharge passage **51**D and the relay effector **53** that controls the oil flow in the second supply and discharge passage **51**E constitute a fluid control portion.

Furthermore, in this lash adjuster **50**, when the control body **52**C is displaced in a direction of closing the pressure receiving-side damper space S**2**, a gap-like orifice portion **55** is formed between the control body **52**C and the inner wall of the pressure receiving-side damper space S**2**. When the pressure-receiving effector **52** is displaced further downward, the abutting portion **52**E at the lower end reaches a state of abutting against the relay effector **53**, and achieves a state of directly transmitting the pressure force from the abutting body **44** to the valve stem **12** of the intake valve **10**.

Operation Mode of Lash Adjuster

When the lash adjuster **50** is in a non-pressing state where the pressure force is not exerted on the pressure-receiving effector **52** from the abutting body **44** of the rocker arm **40**, the valve stem **12** has reached its upper limit due to the biasing force of the valve spring **15**. In this state, the pressure-receiving effector **52** projects due to the biasing force of the intermediate spring **54**, and the second supply and discharge passage **51**E is in a blocked state where the oil flow is blocked. Note that when the first supply and discharge passage **51**D is in a positional relationship in which it is in communication with the fluid space S**1**, the pressure-receiving effector **52** projects upward in a state where the pressure from the oil is also exerted thereon. Accordingly, in this non-pressing state, the pressure-receiving effector **52** projects upward from the sleeve member **51** due to the biasing force of the intermediate spring **54**, and the pressure-receiving roller **52**R is in a positional relationship in which it abuts against the abutting body **44** of the rocker arm **40**. Furthermore, the abutting portion **52**E at the lower end of the pressure-receiving effector **52** is in a positional relationship in which it is separate from the relay effector **53**.

FIG. **8** shows the cross-section of the lash adjuster **50** immediately after the pressure force is exerted on the pressure-receiving effector **52** from the abutting body **44** due to a pivot of the rocker arm **40** and the pressure-receiving effector **52** begins to lower. In a state where the pressure-receiving effector **52** thus begins to lower, the first supply and discharge passage **51**D and the second supply and discharge passage **51**E achieve a blocked state, and the fluid space S**1**, the pressure receiving-side damper space S**2**, and the restoring-side damper space S**3** achieve a state of being in communication with one another. In a state where exertion of the pressure force from the abutting body **44** thus continues, an operation in which the pressure-receiving effector **52** approaches the relay effector **53** against the biasing force of the intermediate spring **54** is performed in a state where the volume of the fluid space S**1**, the pressure receiving-side damper space S**2**, and the restoring-side damper space S**3** does not change.

As a result of this operation being performed, as shown in FIG. **9**, the control body **52**C of the pressure-receiving effector **52** approaches the pressure receiving-side damper space S**2**, the oil is enclosed in the pressure receiving-side damper space S**2**, and the orifice portion **55** is formed between the control body **52**C and the inner wall of the pressure receiving-side damper space S**2**. Thus, the volume of the pressure receiving-side damper space S**2** decreases, a state is reached where the oil enclosed in the pressure receiving-side damper space S**2** leaks into the fluid space S**1** and the restoring-side damper space S**3** from the orifice portion **55**, and the operation of the pressure-receiving effector **52** is suppressed. As a result of reaching this state, the pressure force is transmitted to the pressure-receiving effector **52** via the oil enclosed in the fluid space S**1**, the pressure receiving-side damper space S**2**, and the restoring-side damper space S**3** with lowering of the pressure-receiving effector **52**, and the pressure-receiving effector **52** lowers.

Furthermore, as a result of an increase in the internal pressure of the pressure receiving-side damper space S**2**, a pressure force is exerted in the downward direction on the relay effector **53** from the pressure-receiving effector **52**, and an operation in which the abutting portion **52**E of the pressure-receiving effector **52** approaches the bottom wall portion **53**B of the relay effector **53** is performed. With this operation, a pressure force in the opening direction is exerted on the intake valve **10** from the relay effector **53**, and the intake valve **10** begins to operate in the opening direction.

Then, as a result of the second supply and discharge passage **51**E reaching a position where it is in communication with the restoring-side damper space S**3** due to lowering of the relay effector **53**, as shown in FIG. **10**, a state is reached where the abutting portion **52**E of the pressure-receiving effector **52** abuts against the bottom wall portion **53**B of the relay effector **53** in a state where only the pressure of the oil enclosed in the pressure receiving-side damper space S**2** is exerted on the pressure-receiving effector **52**. Consequently, the pressure receiving-side damper space S**2** functions such that the lowering speed of the pressure-receiving effector **52** at the time of the abutting is suppressed, and an impact-absorbing operation for absorbing the impact at the time of the abutting is realized. As a result of reaching the abutting state, a pivoting force of the rocker arm **40** is transmitted from the pressure-receiving effector **52** to the relay effector **53**, and operates the intake valve **10** in the opening direction.

After the pressure-receiving effector **52** thus abuts against the bottom wall portion **53**B of the relay effector **53** and performs an operation to open the intake valve **10**, when an abutting force of the abutting body **44** of the rocker arm **40** is cancelled and the intake valve **10** begins to operate in the closing direction, a state is reached where the oil is enclosed in the fluid space S**1**, the pressure receiving-side damper space S**2**, and the restoring-side damper space S**3**, as shown in FIG. **11**. When the pressure-receiving effector **52** is displaced in the upward direction, the volume of these spaces does not change, and therefore the pressure-receiving effector **52** performs a projecting operation due to the biasing force of the intermediate spring **54**.

As a result of the pressure-receiving effector **52** operating in the upward direction due to the biasing force of the intermediate spring **54**, a state of causing the pressure-receiving roller **52**R to abut against the abutting body **44** is maintained. Furthermore, with this operation of the pressure-receiving effector **52**, a state is reached where the pressure receiving-side damper space S**2** and the restoring-side damper space S**3** are closed, as shown in FIG. **12**. In this state, the biasing force of the valve spring **15** is exerted in a direction of elevating the relay effector **53**. However, a state is achieved where the oil is enclosed in the restoring-side damper space S**3** sandwiched between the step-like face **51**S of the sleeve member **51** and the upper end face **53**S on the upper-end outer circumference of the relay effector **53**, and therefore the elevating speed of the relay effector **53** is suppressed. Consequently, an outflow of the oil from the restoring-side damper space S**3** is suppressed even in a situation where the biasing force of the valve spring **15** is exerted, and therefore the elevating speed of the relay effector **53** is suppressed, and the impact at the time when the valve head **11** of the intake valve **10** abuts against the valve seat **16** is absorbed.

Control Configuration, Control Mode

As shown in FIG. **1**, the engine control unit **60** includes an input system that acquires a detection signal of the pedal sensor **62** and a detection signal of the angle sensor **34**, and also includes an output system that performs output for controlling the actuator A. The engine control unit **60** has table data or the like for setting the pivoting amount of the control member **32** to a target value in accordance with a detected value acquired by the pedal sensor **62**, and has a program for operating the actuator A based on this table data or the like.

With this configuration, when controlling the air intake amount based on an operation of the accelerator pedal **61**, if it is determined based on a result of the detection by the pedal sensor **62** that the accelerator pedal **61** is in a non-operating state, the engine control unit **60** sets a target value corresponding to idling rotation based on the detected value of the pedal sensor **62** and executes control of the actuator A such that the angle sensor **34** detects a detected value that matches the target value.

When setting an idling state, the target value is set such that the eccentric support portion **33** is set at a minimum position as shown in FIGS. **1** to **5**. The rocker arm **40** is displaced under this control, and the distance from the position where the abutting body **44** abuts against the pressure-receiving roller **52**R to the pivot axis T is set to the minimum. With this control, as shown in FIG. **4**, the lift amount of the intake valve **10** at the time when the cam portion **22** of the camshaft **20** abuts against the intermediate roller **43** and the rocker arm **40** pivots is set to the minimum (minimum lift amount Lmin).

Next, when it is determined based on a result of the detection by the pedal sensor **62** that a stepping operation has been performed on the accelerator pedal **61**, the engine control unit **60** sets a target value corresponding to the detected value of the pedal sensor **62** and executes control of the actuator A such that the angle sensor **34** detects a detected value that matches the target value.

In this control, when, for example, the stepping operation is performed up to the highest speed position, the target value is set such that the eccentric support portion **33** is set at a maximum position, as shown in FIGS. **6** and **7**, and as a result of this control, the rocker arm **40** is displaced, and the distance from the position where the abutting body **44** abuts against the pressure-receiving roller **52**R to the pivot axis T is set to the maximum. As a result of this control, as shown in FIG. **7**, the lift amount of the intake valve **10** at the time when the cam portion **22** of the camshaft **20** abuts against the intermediate roller **43** and the rocker arm **40** pivots is set to the maximum (maximum lift amount Lmax).

Operation Mode Based on Setting of Eccentric Support Portion

In this valve control mechanism for the engine E, when the eccentric support portion **33** is set at the maximum position, the abutting portion **52**E at the lower end of the pressure-receiving effector **52** abuts against the relay effector **53** as shown in FIG. **6**, in a state where the intermediate roller **43** of the rocker arm **40** comes into contact with a circumferential portion (base circle) of the cam portion **22** of the camshaft **20**. In contrast, when the eccentric support portion **33** is set at the minimum position, the abutting portion **52**E at the lower end of the pressure-receiving effector **52** moves away from the relay effector **53** as shown in FIG. **2**, in a state where the intermediate roller **43** of the rocker arm **40** comes into contact with the circumferential portion (base circle) of the cam portion **22** of the camshaft **20**.

FIG. **13** shows a graph with a horizontal axis indicating the rotation angle of the camshaft **20** and a vertical axis indicating the valve lift amount (opening amount of the intake valve **10**) in the case of changing the set position of the eccentric support portion **33**. As shown in FIG. **13**, when the eccentric support portion **33** is set at the maximum position, the intake valve **10** performs an opening and closing operation in conformity with a reference trajectory that reflects the profile of the cam portion **22** of the camshaft **20**, and the intake valve **10** is opened by the maximum lift amount Lmax. When the eccentric support portion **33** is gradually displaced from the maximum position to the minimum position, the intake valve **10** performs an operation in conformity with a trajectory in a mode obtained by shifting the reference trajectory downward (only the upper part of the trajectory). When the eccentric support portion **33** is set to the minimum position, the intake valve **10** performs an operation in conformity with a trajectory in a mode of shifting the reference trajectory significantly downward, and the intake valve **10** is opened by the minimum lift amount Lmin.

That is to say, when the eccentric support portion **33** is displaced from the maximum position to the minimum position, an operation that reflects the shape of the cam portion **22** in the vicinity of a raised face (cam nose) thereof is performed. For this reason, as the eccentric support portion **33** is set closer to the minimum position, a mode appears in which the intake valve **10** operates in conformity with a trajectory obtained by shifting the reference trajectory downward (upper area of the trajectory).

Accordingly, in a state where the eccentric support portion **33** is set at the minimum position, the abutting portion **52**E at the lower end of the pressure-receiving effector **52** moves away from the relay effector **53** as shown in FIG. **2**, at the timing of the intermediate roller **43** coming into contact with the circumferential portion (base circle) of the cam portion **22** of the camshaft **20** with a rotation of the camshaft **20**, and the intake valve **10** maintains the closed state (FIG. **13** (II)). Furthermore, at this timing, the lash adjuster **50** achieves a positional relationship in which, due to the pressure of the oil supplied to the fluid space S**1** and the biasing force of the intermediate spring **54**, the pressure-receiving effector **52** projects upward and abuts against the abutting body **44** of the rocker arm **40**.

Next, at the timing of the intermediate roller **43** abutting against a raised portion of the cam portion **22** and the pressure force being exerted on the pressure-receiving effector **52**, the opening operation of the intake valve **10** is started as shown in FIG. **3** (FIG. **13** (III)). When the pressure force is thus exerted, the lash adjuster **50** performs a series of operations shown in FIGS. **8** to **10** as described above, and thereby reduces the impact at the time when the abutting portion **52**E of the pressure-receiving effector **52** abuts against the bottom wall portion **53**B of the relay effector **53**. That is to say, as described above, the impact is reduced by performing an operation of transmitting the pressure force from the relay effector **53** to the intake valve **10** in a mode of enclosing the oil in the fluid space S**1**, the pressure receiving-side damper space S**2**, and the restoring-side damper space S**3**, and performing an impact-absorbing operation of leaking the oil enclosed in the pressure receiving-side damper space S**2** from the orifice portion **55** with a reduction in the volume of the pressure receiving-side damper space S**2**.

In order to thus reduce the impact, an opening start curve C at the time when the intake valve **10** begins to be opened indicates a low-speed opening operation, unlike a reference curve.

Thereafter, as a result of the pressure force from the pressure-receiving effector **52** being transmitted from the relay effector **53** to the intake valve **10** in a state where the abutting portion **52**E abuts against the bottom wall portion **53**B, the intake valve **10** is opened by the smallest lift amount Lmin as shown in FIG. **4** (FIG. **13**(IV)). At the timing of the pressure force exerted on the intermediate roller **43** from the raised portion of the cam portion **22** being cancelled, the abutting portion **52**E at the lower end of the pressure-receiving effector **52** moves away from the relay effector **53**, and the intake valve **10** is restored to the closed state, as shown in FIG. **5** (FIG. **13**(V)). Furthermore, when the pressure force is thus cancelled, at the time of the closing operation of the intake valve **10**, the impact at the time when the valve head **11** abuts against the valve seat **16** is reduced due to the oil enclosed in the restoring-side damper space S**3**, as shown in FIG.

In order to thus reduce the impact, an opening end curve D at the time of the closing operation of the intake valve **10** indicates a low-speed closing operation, unlike the reference curve.

Similarly, in a state where the eccentric support portion **33** is set at the maximum position, at the timing of the intermediate roller **43** coming into contact with the circumferential portion (base circle) of the cam portion **22** of the camshaft **20**, the intake valve **10** maintains the closed state in a state where the abutting portion **52**E at the lower end of the pressure-receiving effector **52** abuts against the relay effector **53**, as shown in FIG. **6** (FIG. **13**(VI)). Furthermore, at this timing, the lash adjuster **50** achieves a positional relationship in which, due to the pressure of the oil supplied to the fluid space S**1** and the biasing force of the intermediate spring **54**, the pressure-receiving effector **52** projects upward and abuts against the abutting body **44** of the rocker arm **40**.

Next, with a rotation of the camshaft **20**, a pressure force is exerted on the intermediate roller **43** from the time point when the intermediate roller **43** reaches a boundary portion of the raised face (cam nose) of the cam portion **22** from the circumferential portion, and the opening operation of the intake valve **10** is smoothly started. Subsequently, the opening operation is performed with a characteristic that reflects the cam shape of the raised face, as shown in FIG. **7** (FIG. **13**(VII)).

Thus, in a state where the eccentric support portion **33** is set at the maximum position, at the time of the opening operation, a smooth opening operation is performed while a state where the abutting portion **52**E at the lower end of the pressure-receiving effector **52** abuts against the relay effector **53** is maintained. For this reason, the impact-absorbing operation in the lash adjuster **50** is not required, and therefore this impact-absorbing operation is not performed.

EFFECTS OF EMBODIMENT

As described above, with the valve control mechanism of the present invention, the shift amount of the rocker arm **40** in the longitudinal direction is set by controlling the actuator A based on the stepping operation on the accelerator pedal **61**, the lift amount of the intake valve **10** is continuously changed, and the air intake timing of the intake valve **10** can also be changed in conjunction with this change of the lift amount. In particular, since the air intake amount can be adjusted by changing the lift amount of the intake valve **10** without adjusting the air intake amount with a throttle valve, an improvement in fuel efficiency is realized by reducing air intake resistance at the throttle valve, and consequently reducing a pumping loss.

With the configuration of the present invention, a change of the lift amount of the intake valve **10** can be realized due to provision of the configuration in which the base end portion of the rocker arm **40** is supported by the eccentric support portion **33** formed in the control member **32**, the actuator A that rotates the control member **32**, and the angle sensor **34** that detects the rotation angle. For this reason, the number of components of the valve control mechanism can be reduced.

Furthermore, since the rocker arm **40** is provided with the intermediate roller **43** at an intermediate position in the longitudinal direction, when the cam portion **22** of the camshaft **20** abuts against the intermediate roller **43**, smooth abutting is realized and friction is also suppressed due to the rotation of the intermediate roller **43**.

With this configuration, an operation mode is employed in which the abutting body **44** of the rocker arm **40** abuts against the pressure-receiving roller **52**R of the pressure-receiving effector **52** at a high speed. At the time of this abutting, the pressure-receiving roller **52**R rotates, the lash adjuster **50** suppresses the impact at the time when the abutting body **44** of the rocker arm **40** abuts, and a reduction in an impact sound is also realized. Similarly, the lash adjuster **50** also suppresses the impact at the time when the abutting body **44** operates in the direction of moving away from the pressure-receiving roller **52**R and the intake valve **10** operates in the closing direction, and a reduction of an impact sound is also realized. Thus, an engine sound is reduced, and the quietness is improved.

Other embodiments

Embodiments other than the above embodiment may also be employed to configure the present invention.

(a) An actuator configured to operate hydraulically is used as the actuator A provided in the shift unit **30**. With this configuration, control can be realized by using a hydraulic fluid from a hydraulic pump driven by the engine E.

(b) A configuration is employed such that an exhaust valve is controlled using the valve control mechanism of the present invention, as also described in the embodiment. In the case of thus controlling an exhaust valve as well, since the lift speed, the lift amount, and the lift timing can be set arbitrarily, pumping loss is reduced, and exhaust at an optimum timing is realized.

Industrial Applicability

The present invention can be used as an engine valve control apparatus including a rocker arm that abuts against a cam portion of a camshaft.

Reference Signs List

10: Valve, intake valve
20: Camshaft
30: Shift unit
32: Control member
33: Eccentric support portion
40: Rocker arm
43: Intermediate roller
50: Lash adjuster
52: Pressure-receiving effector
53: Relay effector
54: Intermediate spring
55: Orifice portion
61: Accelerator operation tool (accelerator pedal)
60: Control unit (engine control unit)
A: Actuator
E: Engine
Q: Control axis
S2: Pressure receiving-side damper space
T: Pivot axis

The invention claimed is:

1. An engine valve control mechanism, comprising:

a camshaft driven to rotate;

a rocker arm that pivots around a pivot axis of a base end portion of the rocker arm in accordance with a rotation of the camshaft;

a shift unit that shifts the rocker arm in a longitudinal direction of thereof; and

a lash adjuster that abuts against another end portion of the rocker arm and transmits a pressure force from the rocker arm to a valve,

wherein the shift unit includes a control member rotatably supported around a control axis parallel with the pivot axis and pivotably supporting the base end portion of the rocker arm with respect to an eccentric support portion which is eccentric from the control axis, and

the control member rotates around the control axis by an actuator.

2. The engine valve control mechanism according to claim **1**,

further comprising a control unit that, in a case where the valve is configured as an intake valve of an engine and an accelerator operation tool is operated in an accelerating direction, operates the actuator so as to increase an amount of air intake by the intake valve with an increase in an operation amount of the accelerator operation tool and shifts the rocker arm.

3. The engine valve control mechanism according to claim **1**,

further comprising an intermediate roller provided rotatably around an axis parallel with the pivot axis, in an intermediate part of the rocker arm and at a position where a cam portion of the camshaft can abut against the intermediate roller.

4. The engine valve control mechanism according to claim **3**,

wherein the intermediate roller is always in contact with the cam portion.

5. The engine valve control mechanism according to claim **1**,

wherein the lash adjuster has, in a relatively movable manner, a pressure-receiving effector that operates when receiving a pressure force from the rocker arm, and a relay effector that transmits an operating force from the pressure-receiving effector to the valve, and has an intermediate spring that biases the pressure-receiving effector and the relay effector in separate directions, and

the lash adjuster has an orifice portion that suppresses, when the pressure-receiving effector is displaced in a direction of approaching the relay effector, an outflow of a fluid from a pressure receiving-side damper space formed in an insertion portion where the pressure-receiving effector and the relay effector are fitted to each other.

6. The engine valve control mechanism according to claim **5**,

wherein an abutting body of the rocker arm is always in contact with a pressure-receiving roller provided in the pressure-receiving effector.

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